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THINNING WESTERN LARCH

by

ARTHUR L. ROE and WYMAN C. SCHMIDT

DIVISION OF FOREST DISEASE AND
TIMBER MANAGEMENT RESEARCH

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
FOREST SERVICE
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THINNING WESTERN LARCH

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INTRODUCTION

Overstocking threatens production on more than 1 million acres of western larch (Larix occidentalis Nutt.) in the northern Rocky Mountains. Dense stands have developed on favorable seedbeds found on many large burns and cutover areas in this region. The great number of stems in many of these stands precludes optimum growth and development of individual trees because growth is being distributed over too many stems per acre. These trees are likely to remain overcrowded for long periods if stands are unmanaged. Trees in such stands will not reach commercially desirable size within a reasonable time. The obvious solution to the overstocking problem is thinning.

Few western larch stands have been thinned, and little information has been published on thinnings in larch. Forest managers are now guided principally by information developed in other forest types. This paper reports results of two western larch thinning studies located on the Lolo National Forest in western Montana. Briefly, the results show that diameter, basal area, height, and cubic-foot volume growth can be improved by thinning. Concentrating growth on fewer trees per acre will produce larger trees earlier.

DESCRIPTION OF STUDIES

West Fork Plots [1]

Five plots were established in the West Fork of Petty Creek on the Lolo National Forest, at an elevation of about 4,200 feet. Slopes on plot locations range from 25 to 55 percent, and exposures are principally north to northeast. The average site index of the area, determined by using Cummings' site classification curves,[2] is 52 feet at 50 years, or site class III.

The stand originated following a burn and consists principally of western larch trees, with lesser numbers of lodgepole pine and Douglas-fir. Ponderosa pine, Engelmann spruce, grand fir, and subalpine fir are minor constituents only. The stand was about 50 years old when the study was established in 1949. Two crop-tree thinning treatments were applied on four randomly selected ½-acre plots; the fifth plot was left unthinned as a check. Crop trees were chosen on all the plots at the rate of about 150 per acre, spaced roughly 15 feet apart. Preference was given to western larch, ponderosa pine, Douglas-fir, and lodgepole pine, and in that order. As far as possible, only dominant and codominant trees of good form and fair to good vigor were left. The treatments were:

1. On plots 1 and 2, the "D+4" rule of thumb was applied to individual crop trees. All trees were cut around each crop tree for a radial distance in feet equal to the diameter of the tree in inches plus 4.

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[1] Robert A. Smart, former District Ranger, Lolo National Forest, furnished valuable cooperation in this study; and Kenneth Boe, formerly with the Intermountain Forest and Range Experiment Station, prepared the study plan and installed the plots.

[2] Cummings, L. J. Larch--Douglas-fir board-foot yield tables. U.S. Forest Service, Northern Rocky Mountain Forest and Range Expt. Sta. Applied Forestry Note 78, 3 pp., illus. 1937.

2. On plots 3 and 4, trees were cut for a radius of 3 to 6 feet from the crown edge on at least three sides of each crop tree.

3. Plot 5 was left unthinned, but crop trees were marked for later comparison.

Trees were removed in October 1949 by cutting, axe girdling, and poisoning. Those smaller than 5 inches d.b.h. were cut with axes; those 5 inches and larger were girdled on plots 2 and 4, and poisoned on plots 1 and 3.

All larch and ponderosa pine crop trees were pruned with pole saws to a height of about 18 feet to include one log length.

Pattee Canyon Plots[3]

These three plots were located in Pattee Canyon east of Missoula, Montana, on the Lolo National Forest, at an elevation of about 4,600 feet. They were situated on a 15- to 20-percent north-facing slope. The average site index of the area, determined by using Cummings' site classification curves, is 44 feet at 50 years, or site class IV. This stand also originated following a burn and consists of nearly pure larch. Douglas-fir and ponderosa pine comprise less than 5 percent of the total number of trees. The stand was about 30 years old when the treated plot was thinned in 1932.

1. Plot 1, one-fourth acre in size, was thinned from below by removing all of the suppressed and part of the intermediate trees from the stand (grade B, low thinning). This left 876 of the original 2,468 trees per acre, at a spacing of approximately 7 by 7 feet.

2. Plots 2 and 3, one-twentieth and one-fiftieth acre, respectively, were laid out and trees were measured in 1949, because no control plots were established in 1932 when plot 1 was thinned. The locations of these plots in the stand had been considered in 1932, but no measurements were taken then. Growth for the previous 17 years was determined from increment borings in green trees and by recording dead trees in the stand. The numbers and diameters of trees on these unthinned plots in 1932 were calculated from the mortality, growth, and bark data obtained in 1949. We believe that a reasonably reliable estimate of the 1932 stand resulted.

Analysis

Thinning in the West Fork study was aimed at favoring individual trees. Therefore, the analysis was based upon records of individual crop trees. Multiple regression analysis was used to adjust for individual tree growth responses by treatments represented on the plots.

Analysis of the Pattee Canyon plots was based upon data from all trees because it was a uniform thinning.

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[3]The original thinning plot was established by Millard C. Evenson in 1932, while he was a student at the Forestry School, Montana State University, and two small control plots were established in 1949.

RESULTS

Results of thinnings in the moderately overstocked West Fork stand and the heavily overstocked Pattee Canyon stand are presented in tables 1 and 2. These two studies provide 10-year results of "crop-tree" thinning (West Fork) and 27-year results of uniform thinning (Pattee Canyon). Plot means on West Fork do not readily show relative growth responses because of initial inequalities in average d.b.h. However, individual tree analysis shows significant differences that are masked in the stand means. Growth response to thinning is obvious in the Pattee Canyon plots and is proportionate to the degree of stocking (table 2).

Table 1.--Total per-acre stocking in West Fork before thinning in 1949 and crop-tree stocking per acre after thinnings in 1949 and 1959

Treatment and plot number		Before thinning (all trees): Mean d.b.h.	Before thinning: Trees	Before thinning: Basal area	After thinning (crop trees only): Mean d.b.h. 1949	Mean d.b.h. 1959	Mean total height 1949	Mean total height 1959	Trees 1949	Trees 1959	Basal area 1949	Basal area 1959	Volume[1] 1949	Volume[1] 1959
		Inches	Number	Sq. ft.	- - Inches - -		- - - Feet - - -		- - Number - -		- - Sq. ft. - -		- - Cu. ft. - -	
D+4	(1)	3.4	1,586	103	5.3	7.0	44	55	198	188	34	50	610	1,077
D+4	(2)	3.8	1,386	111	5.6	6.7	50	60	188	176	33	43	664	963
Crown	(3)	3.9	1,410	118	5.8	6.8	48	59	168	168	32	42	656	945
Crown	(4)	3.2	1,886	106	5.7	7.0	47	56	174	172	34	46	665	1,026
Unthinned	(5)	3.9	1,668	135	6.0	7.1	52	62	164	164	36	45	753	1,069

[1] Cubic-foot volume on crop trees 2.4 inches d.b.h. and larger, peeled volume, including stump, stem, and top.

Table 2.--Total per-acre stocking in Pattee Canyon before thinning in 1932 and after thinning in 1932 and 1960

Treatment and plot number	Before thinning (all trees): Mean d.b.h.	Before thinning: Trees	Before thinning: Basal area	Before thinning: Volume[1]	After thinning (all trees): Mean d.b.h. 1932	Mean d.b.h. 1960	Mean total height 1949[2]	Mean total height 1960	Trees 1932	Trees 1960	Basal area 1932	Basal area 1960	Volume[1] 1932	Volume[1] 1960
	Inches	Number	Sq.ft.	Cu.ft.	- - Inches - -		- - Feet - -		- - Number - -		- - Sq. ft. - -		- - Cu. ft. - -	
Thinned (1)	([3])	2,468	([3])	878	3.3	5.1	42	50	876	824	57	132	660	2,666
Unthinned (2)	2.1	3,020	95	971	2.1	3.8	37	42	3,020	1,660	95	153	971	2,596
Unthinned (3)	1.4	7,500	102	742	1.4	2.6	31	37	7,500	3,050	102	140	742	1,894

[1] Includes all trees 0.6 inch d.b.h. and over, peeled volume, including stump, stem, and top.
[2] The unthinned plots were not measured until 1949.
[3] Data not available.

Diameter Growth

Diameter growth of individual trees in the West Fork plots increased promptly and significantly following thinning. Average diameter growth of trees on all four thinned plots either equalled or exceeded growth of trees on the unthinned plot (see table 3). Analysis of the individual trees shows that when trees of equal initial diameter are compared, the growth per tree was better on the thinned plots than on the unthinned. A multiple regression analysis relating basal area and diameter before thinning to 10-year growth after thinning, shows that growth response of individual trees is related to the basal area stocking of the plots prior to thinning (fig. 1). For example, 6-inch trees ranged from 0.64-inch d.b.h. growth per decade on the unthinned plot to a high of 1.06 inches for the same period on the heavily thinned plot (plot 1). Therefore, in this individual tree class, the trees in the heavily thinned plot showed a 65-percent greater d.b.h. growth than those on the check plot.

Table 3.--Ten-year growth per acre, crop trees only (West Fork)

Treatment and plot number		D.b.h.	Height	Basal area	Volume
		Inches	Feet	Sq. ft.	Cu. ft.
D+4	(1)	1.6	10.9	16.0	467
D+4	(2)	1.1	9.6	10.0	298
Crown	(3)	1.0	10.3	9.5	289
Crown	(4)	1.4	8.6	12.5	361
Unthinned	(5)	1.0	10.1	8.9	316

The individual tree relationship is not evident in the means because of the widely differing range and distribution of crop-tree initial diameters. The varied length of the curves in figure 1 shows the range of initial diameters. The broad range of crop-tree diameters on the unthinned plot (plot 5) results in a larger mean than the means of any of the thinned plots. The low means for plots 2 and 3 are the result of rather restricted distribution (short curves) shown for these two plots.

Diameter growth can be visualized in another way by considering the change in the range of plot means. For example, in 1949 the largest mean diameter (plot 5, unthinned) was 13 percent greater than the smallest (plot 1, D+4). In 1959, at the end of the 10-year growth period, the largest mean diameter (plot 5, unthinned) was only 6 percent greater than the smallest (now plot 2, D+4). Thus, the range of plot means had been narrowed from 13 to 6 percent. The difference between means of plots 1 and 5 was reduced from 13 percent in 1949 to 1 percent in 1959. Thus, the initial difference between the means of these two plots had virtually disappeared. The mean crop-tree diameter of the thinned plots will soon surpass the mean diameter for the unthinned plots if the present growth rates continue.

Diameter growth of trees in the thinned plots in Pattee Canyon increased much more obviously because of the extreme overstocking which existed in the stand before thinning. The unthinned plots show the marked effect of prolonged overstocking (table 4).

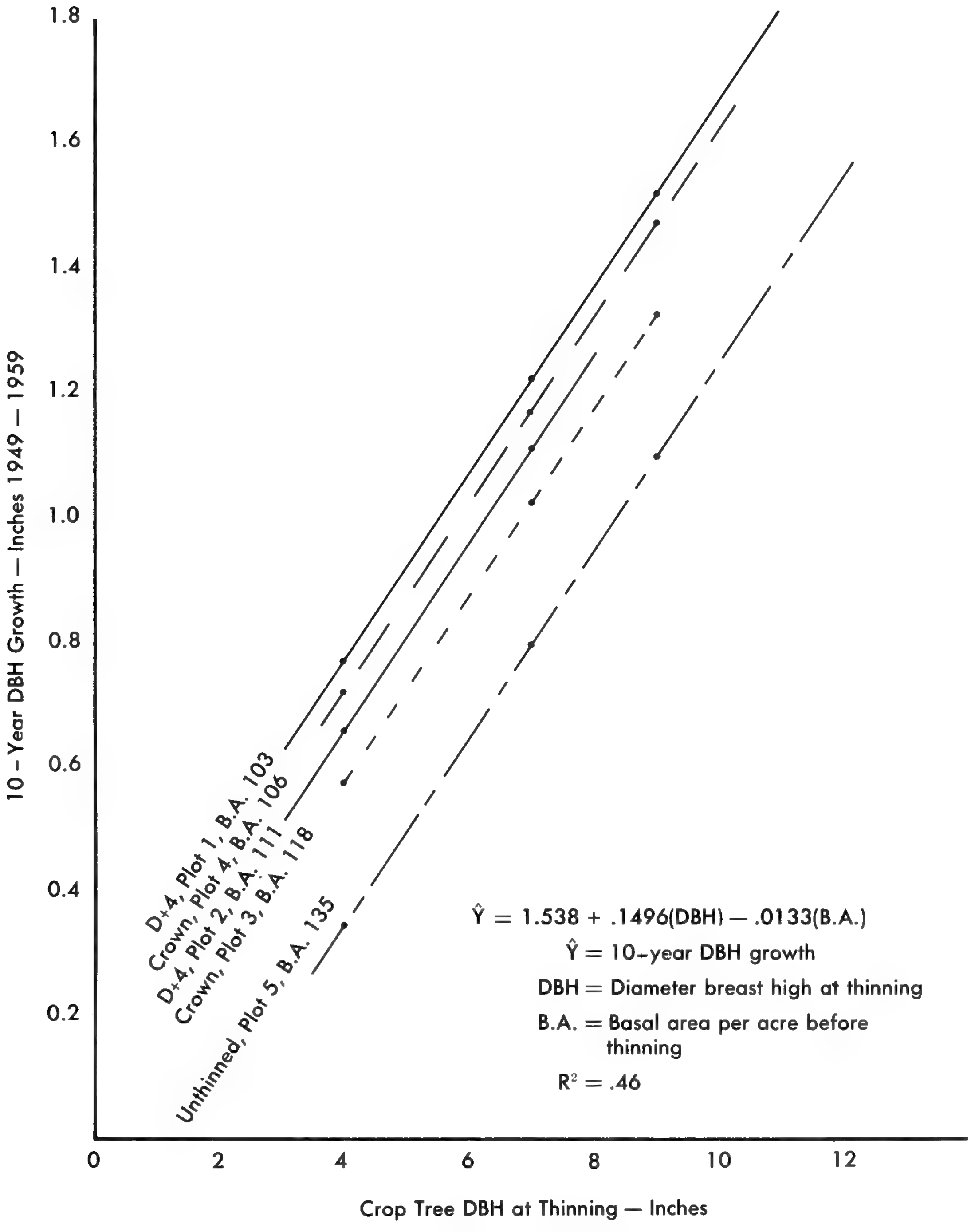


Figure 1.--Relation of 10-year DBH growth of western larch crop trees to DBH and basal area prior to thinning at West Fork.

Table 4.--Growth per acre of all trees in Pattee Canyon plots, 1932-1959

Treatment and plot number		D.b.h.	Height 1949-1960 [1]	Basal area	Volume
		Inches	Feet	Sq. ft.	Cu. ft.
Thinned	(1)	1.8	7.8	74.8	2,006
Unthinned	(2)	1.7	4.7	57.6	1,625
Unthinned	(3)	1.2	5.6	38.4	1,152

[1] Since check plots were not measured until 1949, height growth for 11 years only was available for comparison with the thinned plot.

The effect of thinning on diameter growth in the Pattee Canyon plots was even greater when comparison was based upon equivalent of the 150 largest trees per acre. This comparison showed 56 percent larger diameter growth on the thinned trees than on the unthinned. This indicated that the larger trees responded better to thinning than the smaller trees.

The effectiveness of thinning can be evaluated by comparing actual growth with potential growth for the proper site and age conditions and optimum stocking. A study of normal yield data for western larch has led to the development of a set of curves showing diameter growth of crop trees by age and site index and adjusted for optimum stocking.[4] These curves provide our best estimate of potential growth with a moderately intensive level of management in stands that have never been seriously suppressed.

By determining the section of curve covering the growth periods (age 50-60 in West Fork and age 30-57 in Pattee Canyon) involved in the thinning studies and adjusting to plot site index, the potential diameter curves for the growth period were developed. (See A and B, fig. 2.) For example, curve A in figure 2 is the potential diameter growth curve for crop trees (dominant and codominant trees) at site index 52 and an optimum level of stocking for age 50 to 60 years. Thus the potential 10-year d.b.h. growth for the growth period would be equal to the difference between the 50- and 60-year diameters, or 10.8 inches (60 years) minus 9.0 inches (50 years) = 1.8 inches. The ratio of $\frac{\text{actual d.b.h. growth} \times 100}{\text{potential d.b.h. growth}}$ equals the extent to which the stands have reached this potential.

By comparing actual growth on each plot to the potential growth, the relative improvement due to thinning is evident (table 5). For example, the D+4 treatment increased the diameter growth to 78 percent of the site potential in the first 10-year period following thinning--22 percent closer to the potential goal than the check. During this 10-year period, the trees responded to increased growing space by enlarging their crowns and root systems. About 3 years after thinning, ring width increased noticeably. If the trends continue, greater attainment of the potential goal is expected.

[4] Unpublished data, files of Intermountain Forest and Range Experiment Station.

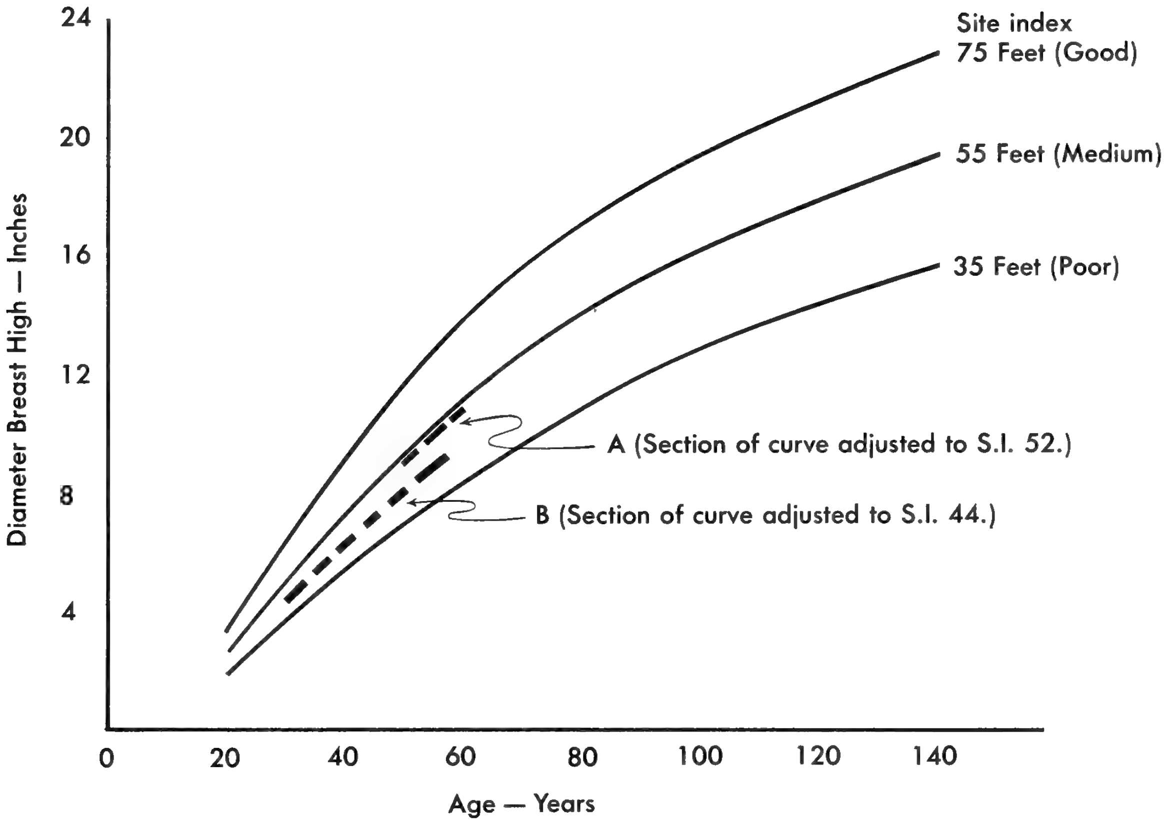


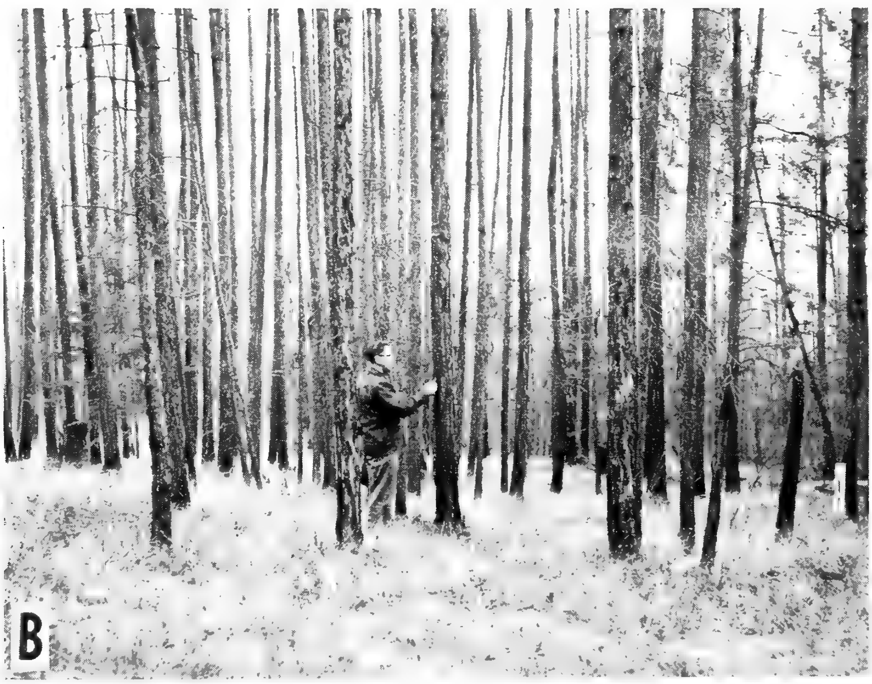
Figure 2.--Potential diameter breast high for western larch by age and site index, adjusted to optimum stocking.

Table 5.--Relation of actual to potential crop-tree diameter growth

Comparison of growth by treatments	West Fork		Pattee Canyon	
	10-year growth	Percent of site potential	27-year growth	Percent of site potential
	Inches		Inches	
Potential growth	1.8	100	4.9	100
Actual growth:				
D+4	1.4	78	--	--
Crown	1.2	67	--	--
Unthinned	1.0	56	--	--
Low thinning, "B" grade	--	--	2.8	57
Unthinned	--	--	1.8	37

The low thinning in Pattee Canyon was too light. Only 57 percent of the goal was attained over a 27-year growth period. However, this is 20 percent better than no treatment (unthinned). More than twice the number of trees per acre were present in the thinned plot at the end of the 27-year growth period than are desirable to obtain potential growth (fig. 3).

Figure 3.--Fifty-seven-year-old western larch on a medium site: A, Heavily overstocked unthinned stand. Both diameter and height growth are suppressed; B, comparable stand thinned from below, 27 years ago, to a 7- by 7-foot spacing. This stand is still overstocked (growing at one-half potential), but diameter and height growth are 50 percent greater than in the unthinned stand.



Basal Area

All thinned plots showed greater basal area increment than the unthinned plots (tables 3 and 4). Basal area relations closely parallel those of diameter growth. This similarity of growth is not unexpected because basal area is a function of diameter. The thinned plot on the Pattee Canyon area grew about 56 percent more basal area in 27 years than the unthinned plots, while the West Fork thinned plots averaged 35 percent more basal area increment than the unthinned plot during the 10-year growth period.

Height

Larch height growth responded to thinning only in the extremely overstocked stands in Pattee Canyon (table 4). The trees on the thinned plot added 48 percent more height during an 11-year growth period than did those on the dense unthinned checks. On the other hand, trees on the thinned plots (1-4) in the moderately overstocked West Fork stand did not show more height growth than those on the check plot (5). Although the rate of height growth varied somewhat in the four thinned plots, no significant trend appeared.

In contrast to western larch, lodgepole pine crop trees in the West Fork plots responded significantly to thinning by a reduction in height growth. Lodgepole pine crop trees in the thinned plots average 30 percent less height increment than those in the unthinned plots (table 6). The response agrees with findings in an earlier lodgepole pine study.[5]

Table 6.--Mean 10-year height growth of western larch and lodgepole pine on West Fork

Treatment and plot number		Western larch	Lodgepole pine
		Feet	Feet
D+4	(1)	11.7	8.9
D+4	(2)	9.7	6.6
Crown	(3)	11.4	5.8
Crown	(4)	8.9	7.5
Unthinned	(5)	10.7	10.3

Cubic-Foot Volume

Cubic-foot volume increment increased following thinning in both studies. This increase was much more obvious in the more densely stocked Pattee Canyon area. Trees on the thinned plot grew from a volume 23 percent smaller than the average of those on the check plots in 1932 after thinning, to a 19-percent greater volume than the trees on the check plots in 1960 (table 2). The volume increase on the West Fork thinned plots is much more subtle, since the smaller initial total crop-tree volumes on the thinned plots have only approached the crop-tree volume on the unthinned plot during the 10-year growth period. Two of the thinned plots now have about

[5]Tackle, D., and R. C. Shearer. Strip-thinning by bulldozer in a young lodgepole pine stand. Mont. Acad. Sci. Proc. 19: 142-148. 1959.

the same volumes as the unthinned plot, while the other two have nearly caught up. To do this, it was necessary for the thinned crop trees to grow faster than those in the unthinned plot. It is expected that this trend will continue, and all the thinned plots may exceed the unthinned plot 10 to 15 years hence.

Cost

The cost of thinning by the D+4 rule in the West Fork area amounted to 20.1 man-hours per acre as contrasted with 15.0 for the crown thinning. These costs are further broken down as follows:

Cutting	-	64.3 trees per man-hour (trees less than 5 inches d.b.h. only)
Girdling	-	23.6 trees per man-hour (trees more than 5 inches d.b.h. only)
Poisoning	-	18.4 trees per man-hour (trees more than 5 inches d.b.h. only)

The D+4 thinning cost more because it resulted in removing more trees than the crown thinning.

Western larch and ponderosa pine trees were pruned to a height of one log at an average rate of 14 trees per hour. This cost was obtained on the $\frac{1}{2}$-acre plots in the West Fork study. Consequently, it may not completely represent practical average rates for such work on larger areas. The crew was better than average; consequently the cost estimate is probably conservative.

No cost records were kept for the low thinning in the Pattee Canyon plots.

DISCUSSION AND RECOMMENDATIONS

These studies show that the main benefit from thinning is obtained by concentrating the growth on fewer stems. The net result is that trees grow to a larger size earlier, and usable volume is realized earlier in the life of the stand. For example, if the present growth rates continue on the Pattee Canyon plots, the thinned trees will reach a 10-inch average diameter at stand age 135 years. The unthinned trees, on the other hand, will not reach this average size in less than 200 years, or $1\frac{1}{2}$ times as long.

Recommendations for thinning western larch:

1. Early thinning should be the rule in managing larch stands. Growth response of thinned stands is related to stand structure and stocking prior to thinning. Growth that is lost on individual trees through years of overstocking cannot be regained by thinning. In fact, response to thinning will be slow until the thinned trees develop good crown and root systems. Therefore, stands should be thinned early, before serious competition for moisture and light occurs.

2. The best results are obtained from larch thinnings when first consideration is given to selecting good crop trees. Correct spacing is important, but secondary to crop-tree selection. Dominant and codominant trees consistently show the greatest response to thinning. Therefore, the best practice is to thin from below and reserve the more dominant trees with well-developed vigorous crowns.

3. Where crop-tree thinning is desirable, the D+4 rule applied to individual crop trees as a spacing guide is suggested. If the management objective is to grow sawtimber on a 140-year rotation, crop trees should be selected at the rate of 120 to the acre for site index 65 or more, and 140 to the acre for under site index 65.

Roe, Arthur L., and Wyman C. Schmidt.
1965. Thinning western larch. U.S. Forest Serv. Res. Paper INT-16, 10 pp., illus.

Diameter, basal area, and cubic-foot volume growth of individual trees were improved by crop-tree thinning in 50-year-old and uniform thinning in 30-year-old larch. Height growth increased only in the heavily overstocked 30-year-old stand. Growth response was strongly related to stand structure and stocking prior to thinning: moderately overstocked stands responded rapidly, while heavily overstocked stands responded slowly. Dominant and codominant trees consistently showed the greatest response. Early thinning from below is recommended in larch stands reserving well-developed, vigorous dominant trees.

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Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Project headquarters are also at:

- Boise, Idaho
- Bozeman, Montana (in cooperation with Montana State College)
- Logan, Utah (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with Montana State University)
- Moscow, Idaho (in cooperation with the University of Idaho)
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